Journal of Research on the Lepidoptera 13(1):1-20, 1974

1160 W. Orange Grove Ave., Arcadia, California 91006, U.S.A.

STUDIES ON NEARCTIC *EUCHLOE*

PART 7.

COMPARATIVE LIFE HISTORIES, HOSTS AND THE MORPHOLOGY OF IMMATURE STAGES

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This part of the series deals with certain aspects of the life history of the Nearctic *Euchloe*. Although the "life histories" of all except *Euchloe creusa* have appeared in the literature, no comparisons have been made. This study emphasized the immature stages, important differences in oviposition sites, larval behavior, larval color patterns, larval setation, and pupal configuration.

LIFE HISTORY

Host. — All *Euchloe* oviposit and feed upon maturing plants of the family Cruciferae. The food plants utilized are the result of selection by ovipositing females.

Among the species of Cruciferae which occur at any locality, female *Euchloe* may select more than one species as suitable hosts, but never appear to utilize all of them. Those species selected must have had several prior requirements. These are: (1) the plant should grow in full sunlight, (2) the plant should be more than five inches in height with an erect configuration, and (3) the clusters of unopened flower buds should be terminal and tightly clustered (except some *Euchloe hyantis* hosts).

The role of allyl isothiocyanate levels in determining the suitability of various crucifers as hosts for *Euchloe* is unknown.

The groups of hosts used by most, well-observed species are broad. Qualitative differences in host utilization are pronounced

only between the two species groups. The three members of the "Ausonides group," i.e. *Euchloe ausonides, E. creusa,* and *E. olympia,* tend to utilize species of *Arabis* and "mustard-like" crucifers, i.e. *Arabis glabra, Barbarea, Brassica,* and *Sisymbrium,* while the "Hyantis group," i.e. *Euchloe hyantis,* tends to utilize *Caulanthus, Descurainia,* and *Streptanthus* with greater frequency.

That host specificity levels within the Cruciferae are broad is shown by the frequent utilization of introduced species of the family. Swales (1966) briefly discusses the range extension of some pierids due to the introduction of crucifers into disturbed areas around villages in Arctic Canada. Opler (1969) explained the role of introduced species of *Brassica* as a possible factor permitting the facultative bivoltinism of *Euchloe ausonides* in coastal central California.

All pertinent locality and host data for all Nearctic *Euchloe* are summarized in Table 1.

Oviposition site. — Members of the "Ausonides group" almost always place their eggs on unopened flower buds of the host. This behavioral feature has been reported for *E. ausonides* by Coolidge and Newcomer (1908) and Remington (1952), while Shull (1907) and Meiners (1938) reported the same pattern for *E. olympia.* I have observed many hundreds of eggs of *E. ausonides* and only rarely were eggs found anywhere but on unopened buds. Eggs of *Euchloe creusa* near Banff were all found on unopened flower buds of *Draba lanceolata.*

Although *Euchloe hyantis* females may select flower buds as oviposition sites, other portions of the plant are utilized with greater frequency. Coolidge (1925) reported that eggs of *Euchloe hyantis lotta* were found on flower buds, leaves, or the stems of host plants. Near El Portal, Mariposa County, California, I observed that the eggs of *Euchloe hyantis* were most frequently placed on the lower surface of the saggitate clasping leaves of *Streptanthus polygaloides.*

Larval behavior. — Upon emerging from the egg, larvae of *Euchloe* seek unopened flower buds upon which to feed. J. A. Scott, Division of Entomology, University of California, Berkeley, (Personal communication) states that first instar larvae of *Euchloe ausonides* die if fresh unopened buds are not available. Upon hatching, larvae of *E. hyantis,* emerging from eggs laid on leaves or stems of the host, must find the reproductive portions of the plant soon after hatching. To do this the larvae make

TABLE I.
HOST AND LOCALITY DATA FOR VARIOUS SPECIES OF EUCHLOE

Euchloe ausonides

Arabis drummondi Gray

Canada, Ontario, Geraldton Forest (Thunder Bay District), 28 June 1966. J.C.E. Riotte. Jour. Lepid. Soc., 22(1): 41 (1968).
Colorado, Boulder County, Nederland 6 July 1949. C.L. Remington. Psyche, 59(2):63 (1952).
Colorado, Gunnison County, Gothic, 9600', 10 July 1967, J. Emmel and O. Shields. J. Res. Lepid., 8(1):31 (1970).

Arabis fendleri (Wats.) Greene var. spatifolia (Rydb.) Rollins
Colorado, Boulder County, Nederland, 6 July 1949, CL. Remington. Psyche, 59(2):63(1952).

Arabis glabra (L.) Berh.

Colorado, Boulder County, Spring Gulch, 7 July 1949, C.L. Remington. Psyche, 59(2):62 (1952).
California, Contra Costa County, Berkeley Hills, NE Oakland, 3 June 1963 J.A. Powell. Preserved larvae in California Insect Survey.

Barbarea vulgaris (L.)

California, Contra Costa County, Russelmann Park, Mt. Diablo, 24 April 1966, P.A. Opler. Personal observation.

Brassica campestris L.

California, Contra Costa County, Briones Regional Park, 28 March 1970, P.A. Opler. Personal observation.

Brassica kaber (D.C.)

California, Alameda County, Strawberry Canyon, 18 April 1964, P.A. Opler. Personal observation.
California, Contra Costa County, Briones Hills Regional Park, 28 March 1970, P.A. Opler. Personal observation.
California, Contra Costa County, Tilden Regional Park, 18 April 1968, P.A. Opler. Personal observation.
California, Santa Clara County, Alum Rock Park, 28 February 1964, P.A. Opler. Personal observation.

Brassica nigra (L.) Koch

California, Alameda County, Strawberry Canyon, 10, 15 April 1970, P.A. Opler. Personal observation.
California, Contra Costa County, Pt. Richmond, 18 April 1969, J.A. Scott. (preserved larvae).
California, Santa Clara County, New Almaden, 4 May 1964, P.A. Opler. Personal observation.

Descurainia Californica (Gray) Shultz

Colorado, Gunnison County, Schofield Pass, 10,400', 14, 18 July 1967, J. Emmel and O. Shields. J. Res. Lepid., 8(1):31 (1970).

Erysimum capitatum (Dougl.) Greene

Colorado, Boulder County, Nederland, 6 July 1949, C.L. Remington. Psyche, 59(2):63 (1952).

Isatis tinctoria L.

California, Modoc County, Buck Creek Ranger Station, 11 June 1970, P.A. Opler. Personal observation.

Raphanus sativa L.

California, Contra Costa County, Briones Regional Park, 28 March 1970, P.A. Opler. Personal observation.

Sisymbrium altissimum L.

Colorado, Boulder County, Boulder Canyon, 6500', Mt. Flagstaff, Nederland, 8-9 July 1949, C.L. Remington. Psyche, 59(2):62 (1952).

Euchloe creusa

Draba lanceolata Royle

Canada, Alberta, Moraine Lake, 6800', Banff National Park, 27 June 1965, P.A. Opler. Personal observation.

Euchloe olympia

Arabis drummondii Gray

Michigan, Montcalm County, T12N, R10W, Sec. 19, 20 June 1966, M.C. Nielsen. Preserved larvae in Michigan State University Collection. Michigan. Roscommon County, T24N, R1W, Sec. 3. 5 July 1967, MC. Nielsen. Preserved larvae in Michigan State University collection.

Arabis lyrata L.

Indiana, Lake Michigan dunes between Clarke Junction and Pine, C.A. Shull. Ent. News, 18(3): 73 (1907).
Michigan, Berrien County, T53, R19W, Sec. 29, 29 May, 3-5 June 1967, M.C. Nielsen. Preserved larvae in Michigan State University Collection.

Arabis missouriensis Greene

Missouri, St. Louis County, Ranken, 28 April 1935, E.P. Meiners, Proc. Missouri Acad. Sci., 4:154-156 (1938).

Sisymbrium sp.

West Virginia, 1891, W.H. Edwards, Butterflies of North America.

Euchloe hyantis

Arabis glabra (L.)Bernh.

California, Sierra County, Shenanigan Flat, 14 miles W Downieville, 15 May 1970, P.A. Opler. Personal observation.

Arabis holboellii var. pinetorum (Tides.) Roll.

California, San Bernardino County, Sugarloaf Peak, 8000', July 1970, W. Hovanitz. J. Res. Lepid., 8(1): 17 (1970).

Caulanthus amplexicaulis Wats.

California, Kern County, between Mojave and Randsburg, Coolidge. Ent. News, 19:204-210 (1925).

Caulanthus crassicaulis (Torr.) S. Wats.

California, Modoc County, 5 miles S Ft. Bidwell, 11 June 1970, P.A. Opler. Personal observation.

Descurainia pinnata (Walt.) Britton

California, San Bernardino County, Newberry Mountains, 3/4 mile NW Kane Spring Road, 27 March 1964, J.F. and T.C. Emmel. Letter of 24 November 1964.
California, San Bernardino County, Phelan, J.A. Comstock and C.M. Dammers, Bull. So. Calif. Acad. Sci., 31(2): 35-37 (1937).

Descurainia pinnata var. nelsonii (Rydb.) Detl.

Washington, Benton County, Vernita, 6 April 1966, E.J. New comer. Letter of 20 May 1967.

Isatis tinctoria L.

California, Modoc County, Buck Creek Ranger Station, 11 June 1970, P.A. Opler. Personal observation.

Sisymbrium altissimum L.

Washington, Benton County, Vernita, 22 April 1967, E.J. Newcomer. Letter of 20 May 1967.

Stanleya pinnata (Pursh) Britton

California, Inyo County, Wildrose Station, Panamint Mountains, 15 May 1969, P.A. Opler. Personal observation.

Streptanthella longirostris (Wats.) Rydb.

California, San Bernardino County, Phelan, J.A. Comstock and C.M. Dammers. Bull. So. Calif. Acad. Sci., 31(2): 35-37 (1935).

Streptanthus bernardinus (Greene) Parish

California, San Bernardino County, Lake Arrowhead, 5000', 29 June 1966, C. Henne. Letter of 7 July 1966.

Streptanthus polygaloides Gray

California, Mariposa County, 2 miles W El Portal, 12 April 1964, P.A. Opler. Personal observation.

Streptanthus tortuosus Kell.

California, Sierra County, Shenanigan Flat, 14 miles W Downieville, 15 May 1970, P.A. Opler. Personal observation.

Streptanthus sp.

California, Alpine County, Hope Valley, 9 July 1949, J.W. MacSwain, Preserved larvae in California Insect Survey.
California, Siskiyou County, Little Castle Lake, 20 July 1969, P.A. Opler. Personal observation.
California, Tuolumne County, Lodgepole Campground, Sonora Pass, 2 July 1966, P.A. Opler. Personal observation.

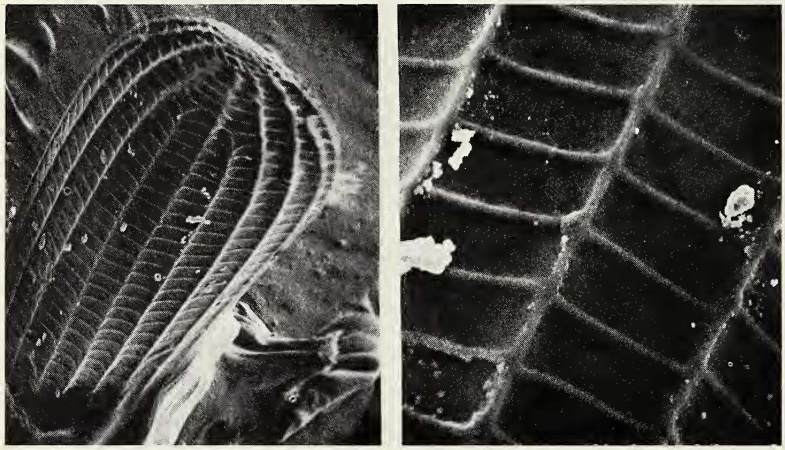

Fig. 1.
Left, egg of *Euchloe ausonides,* 100 X. Strawberry Canyon, Alameda Co., Calif.; right, same, 500 X. Stereoscan electron photomicrographs by Wayne Steele.

geo-negative or photo-positive movements. On *Streptanthus polygaloides* young larvae of *Euchloe hyantis* bore through the clasping leaves lying between the site of oviposition and flowering portions of the plant. During this movement the larvae do not pause to feed on leaf material.

Young larvae of *Euchloe* feed upon unopened flower buds and flowers. During this period the larvae are comparatively hidden. The young larvae of *E. ausonides* station themselves vertically amongst the flower cluster and always cover the portion of the plant upon which they rest with loosely spun silk.

The first instar larvae of *Euchloe hyantis* were found to have another anomolous habit which seems to be an adaptation to feeding upon *Streptanthus*. The calyx of *Streptanthus* flowers is almost closed distally. In order to reach the inside of the calyx the young larva bores a small hole through the side of the calyx, enters, and feeds upon the flower from within.

Older larvae feed in more exposed positions and include the seed pods in their diet. While feeding upon seed pods the larvae orient with their anterior end directed toward the apical end of the pods.

Pupation. — The final stages of ecdysis which lead directly to pupation in *Euchloe* seem to occur in a characteristic manner that holds true for all species of *Euchloe,* and probably take place in much the same fashion for all members of the tribe Euchloini. When the larva has finished feeding it commences a search for a suitable pupation site which is usually located on the food plant. Upon finding a pupation site the larva attaches itself by means of a caudal button of silk and silk girdle with the anterior portion at a higher elevation than the posterior. Pupation then takes place between 24 and 72 hours later. At a time varying from just prior to the wandering phase to a time subsequent to being stationed in the pupation position, the larva becomes purplish in color. A quantitative lack of observations prevents the determination of the specificity of any of the above phenomenon. The appropriate passages from the literature upon which the above narration was based are cited below. Shull (1907), in regard to the mature larva of *Euchloe olympia,* said "Shortly a purplish tinge makes its appearance at the posterior end and about the thorax. The color gradually extends anteriorally until the whole body shows it. This change immediately precedes and accompanies the wandering of the larva seeking a place to pupate."

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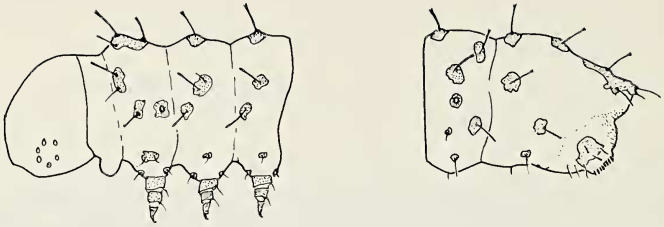

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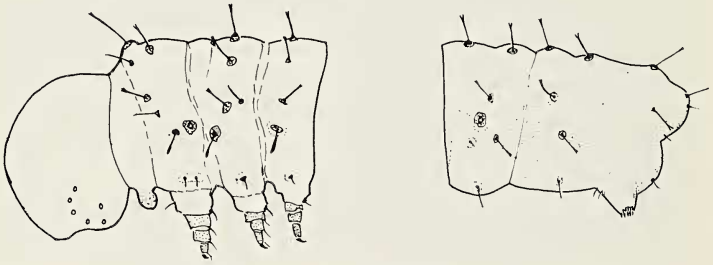

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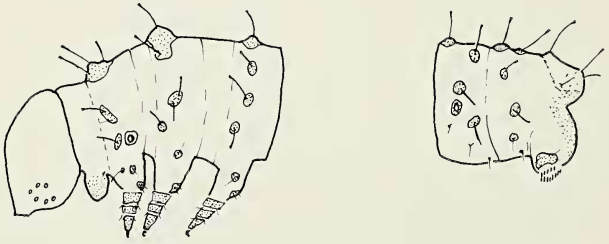

First instar larvae, segments T 1-3, A 9-10. Fig. 2, *Euchloe ausonides,* Alum Rock Park, Santa Clara Co., Calif.; Fig. 3, *Euchloe creusa,* Moraine Lake, Banff National Park, Alberta, Canada; Fig. 4, *Euchloe olympia,* Berrien Co., Mich.

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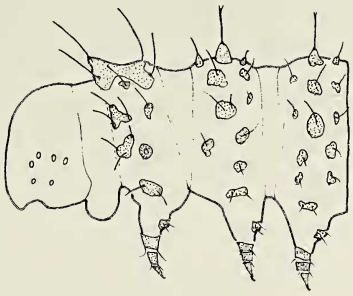

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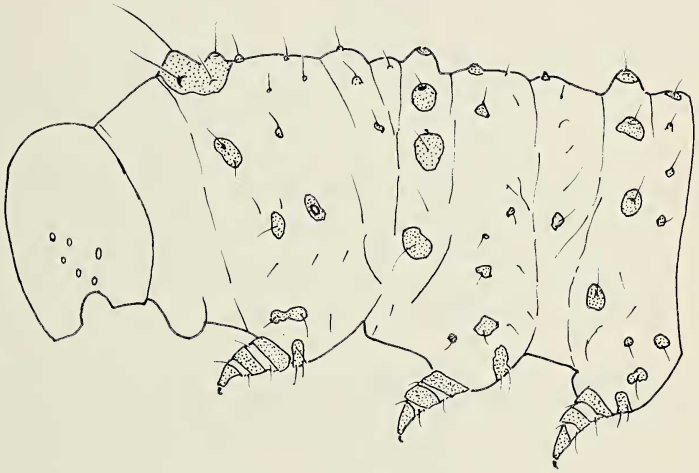
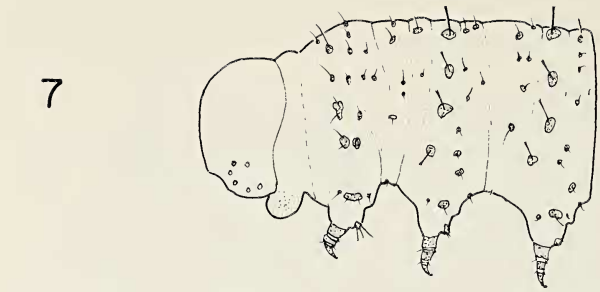
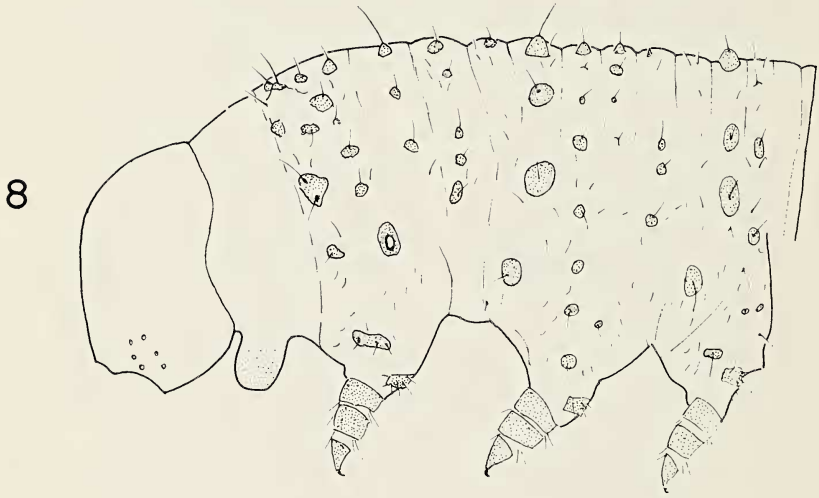
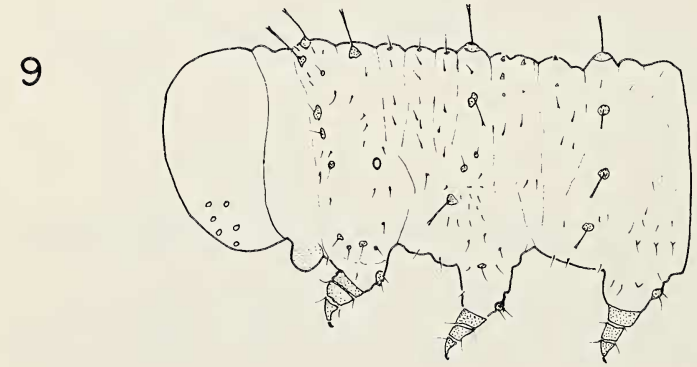


Second instar larvae, segments T 1-3, A 9-10. Fig. 5, *Euchloe ausonides*, Buck Creek Ranger Station, Modoc Co., Calif.; Fig. 6, *Euchloe olympia*, Montcalm Co., Mich.







Third instar larvae, segments T 1-3, A 9-10. Fig. 7, *Euchloe ausonides,* Buck Creek Ranger Station, Modoc Co., Calif.; Fig. 8, *Euchloe olympia,* Montcalm Co., Mich.; Fig. 9, *Euchloe hyantis,* Buck Creek Ranger Station, Modoc Co., Calif.

Mead (1877) described the pupation of *Euchloe hyantis* based upon observation of larvae collected in Yosemite Valley, Mariposa County, California, as follows, "Just before the change to chrysalis the caterpillar turns dull purple. The chrysalis retains this color for a day or two and then gradually assumes a waxy grayish white color." Coolidge (1925) noted that the larva of *Euchloe hyantis lotta* "becomes solid purplish red" just prior to pupation. Comstock and Dammers (1932), while describing the larvae of *Euchloe hyantis lotta,* stated that "a short time prior to pupation they turn a mottled dark maroon over the dorsal and lateral surface above the stigmatal line. Pupation occurs on the food plant as in *Anthocharis cethura.*" (i.e. with a girdle, caudal button, and the head pointing upward, *fide* Comstock and Dammers).

MORPHOLOGY OF IMMATURE STAGES

Egg. The eggs are typical of Euchloini in being columnar with the micropylar area broadly rounded. The eggs have from 15-20 prominent vertical ridges which are interconnected by less prominent horizontal ridges (Fig. 1.).

The eggs undergo a series of progressive color changes as the embryo develops. Coolidge and Newcomer (1908), while describing the life history of *Euchloe ausonides*, stated that the "color when first laid (was) light bluish green changing in 24-30 hours to light orange. By the third day the color is almost vermilion, and about the sixth day the egg turns dirty yellow brown, especially so apically."

Larva. — The larvae of *Euchloe* differ interspecifically and interstadially in features of color and setation. These differences will be systematically discussed below.

The sequence of color changes undergone by the larvae of *Euchloe ausonides* (Coolidge and Newcomer, 1908) and *Euchloe olympia* (Shull, 1907) is parallel.

The first instar larva is orange-yellow with a black head, while the second instar larva is greenish with a black head. Markings typical of the final three instars are discernible on the third instar larva: a gray-green dorsal stripe, yellow-green subdorsal stripes, gray-green supraspiracular stripes, yellow spiracular stripes, and subspiracular and ventral areas green. The head of the third instar larva is green-black. The fourth instar larva of the two species has the same markings, but the head capsule

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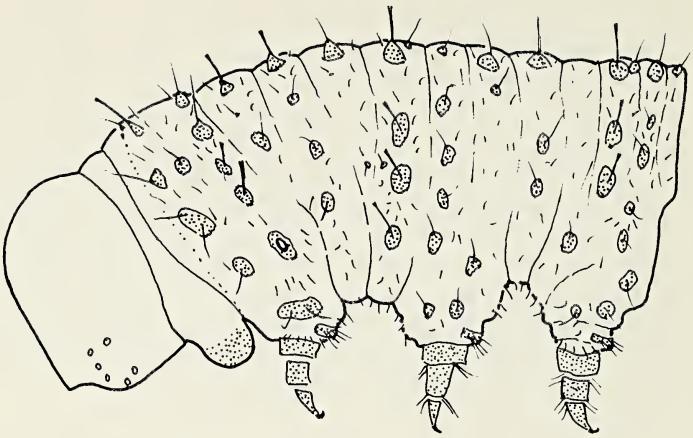

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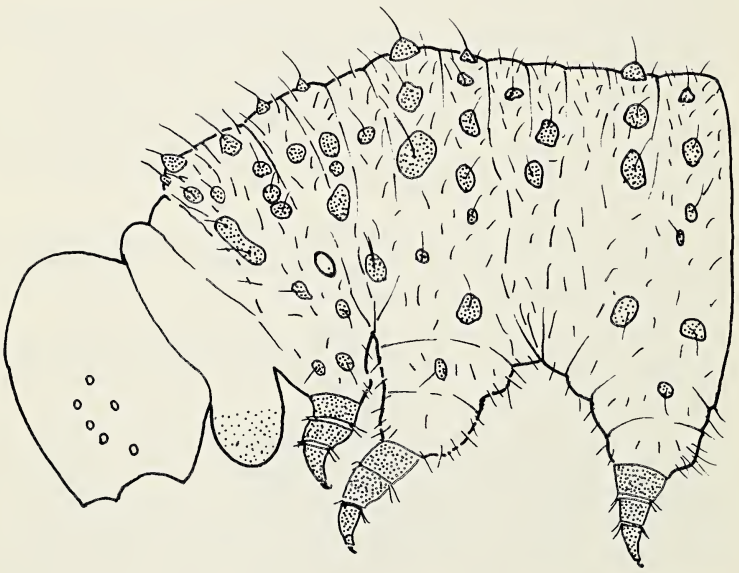

Fourth instar larvae, segments T 1-3, A 9-10. Fig. 10, *Euchloe ausonides*, Buck Creek Ranger Station, Modoc Co., Calif.; Fig. 11, *Euchloe olympia*, Montcalm Co., Mich.

is greenish gray. The spiracular stripe of the fifth instar larva is white and is subtended with pale yellow. Plate 1, figs. 1, 6.

Larvae of *Euchloe hyantis* undergo a similar series of changes, but have a different color pattern. The color pattern of the last three instar larvae is distinctive. The dorsal area is green (occasionally with a narrow purplish line). The subdorsal area is also green, while the supraspiracular area is purplish. The spiracular area is white or yellow. The subspiracular and ventral areas are green. The head capsule is green. Interpopulation variation of larval color pattern in *Euchloe hyantis* was noticed, while larval coloration of *Euchloe ausonides* and *E. olympia* varies within very narrow limits. Plate 1, figs. 3, 5.

The spiracular stripe is white in most populations of *Euchloe hyantis*, but may be yellow in some populations in the western foothills of the Sierra Nevada. The color of the dorsal and subdorsal areas is also variable. In most populations (Vernita, Wash.; cismontane Calif.) these areas are green, while these areas are grayish in some Great Basin populations (John Emmel, 1117 9th St., Apt. 207, Santa Monica, Ca. 90403, per. com.) and yellowish-green in the San Bernardino Mountains population (Chris Henne, P. O. Box 1, Pearblossom, Calif., personal communication).

Chaetotaxic line drawings of *Euchloe* larvae are presented as figures 2-15. These drawings portray the three thoracic segments for all larvae as well as the eighth and ninth abdominal segments for first instar larvae. The microscopic primary setae (Hinton, 1946) are not necessarily portrayed.

Certain primary setae on the dorsal, subdorsal, and lateral areas are thickened and may be cleft at their apices. Coolidge (1925) reported that the setae of *Euchloe hyantis* supported "hyaline drops of fluid," while Shull (1907) reported that the setae of *Euchloe olympia* were glandular. If the forked setae do exude secretions, it would be of extreme interest to know what is their funtion and composition.

Prothoracic segment setae XD1, D2, XD2, SD1, SD2, and L1, mesothoracic setae D1, D2, SD1, SD2, and L1 are thickened and cleft in the *Euchloe* larvae.

The subdorsal group of primary setae on the prothoracic segment occurs on the same sclerotized chalaza for almost all larvae of the "Ausonides group," but occur on separate chalazae on *Euchloe hyantis* larvae.

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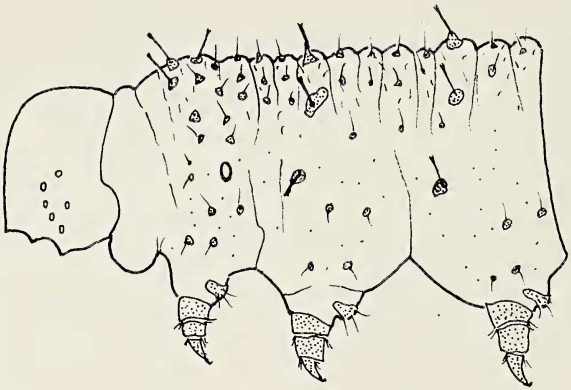

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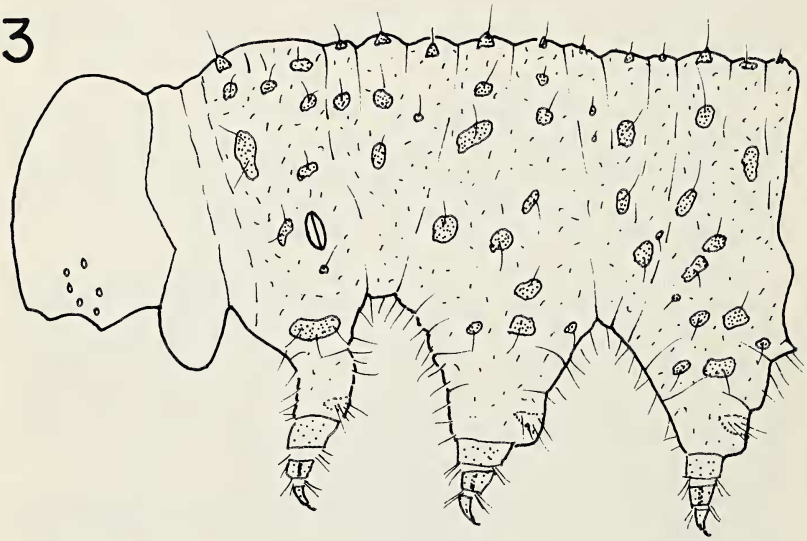
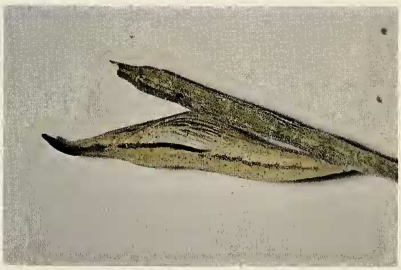
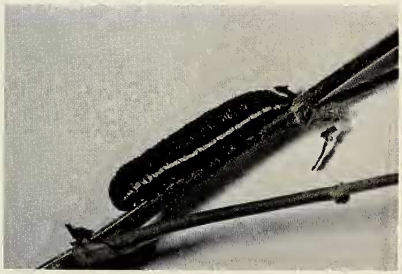


Fourth instar larvae, segments T 1-3, A 9-10. Fig. 12, *Euchloe hyantis,* Buck Creek Ranger Station, Modoc Co., Calif. Fifth instar larvae, segments T 1-3, A 9-10, Fig. 13, *Euchloe ausonides,* Buck Creek Ranger Station, Modoc Co., Calif.





Color Plate 1.

1. *Euchloe ausonides,* 5th instar, Briones Regional Park, Contra Costa Co., Calif.; 2. *Euchloe ausonides,* pupa, Briones Regional Park, Contra Costa Co., Calif.; 3. *Euchloe hyantis,* 5th instar, Shenanigan Flat, Sierra Co., Calif.; 4. *Euchloe hyantis,* pupa, Shenanigan Flat, Sierra Co., Calif.; 5. *Euchloe hyantis,* 5th instar, near Fallon, Nevada, collected by J. F. Emmel; 6. *Euchloe hyantis,* prepupa, Shenanigan Flat, Sierra Co., Calif. (upside down).

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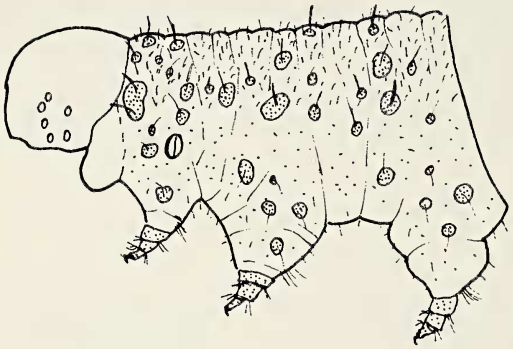

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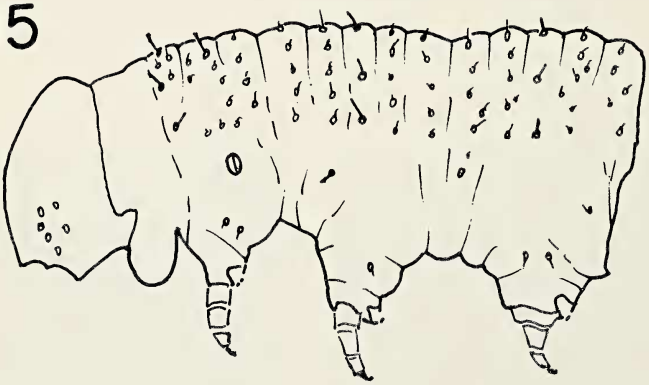
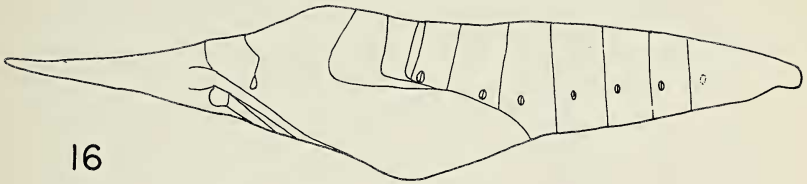
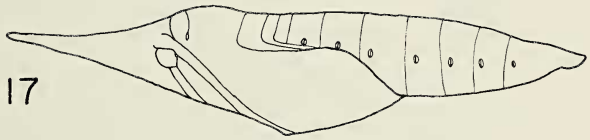


Fifth instar larvae, segments T 1-3, A 9-10. Fig. 14. *Euchloe olympia,* Roscommon Co., Mich.; Fig. 15, *Euchloe hyantis,* Buck Creek Ranger Station, Modoc Co., Calif.





Pupae, lateral aspect. Fig. 16, *Euchloe ausonides,* Strawberry Canyon, Alameda Co., Calif.; Fig. 17, *Euchloe olympia,* Montcalm Co., Mich.; Fig. 18, *Euchloe hyantis,* El Portal, Mariposa Co., Calif.

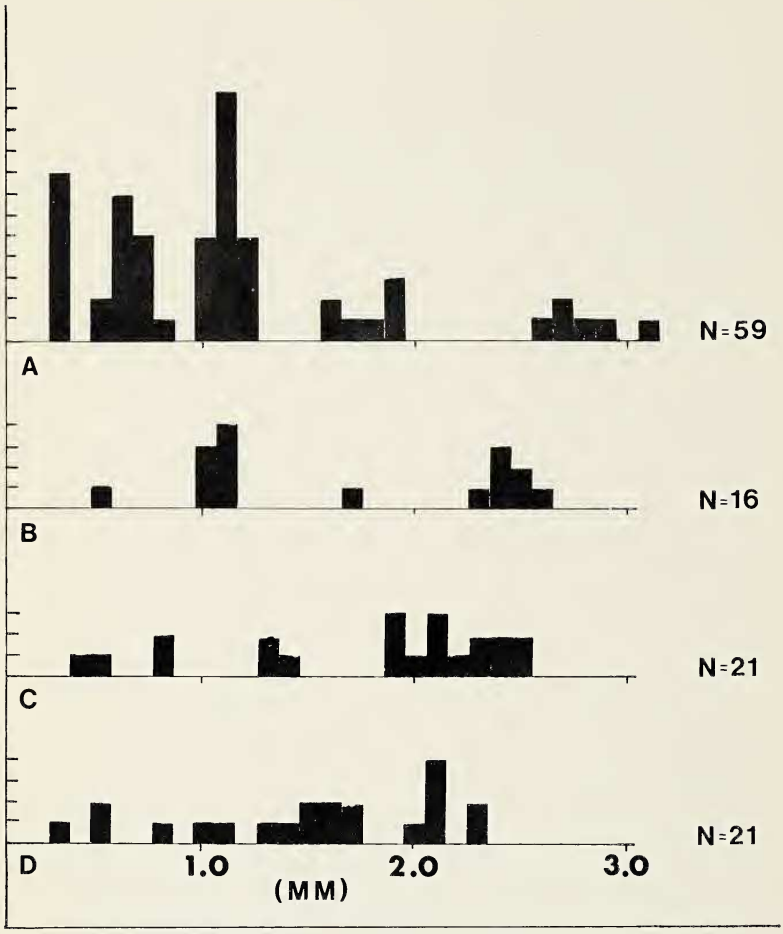


Fig. 19 —Bar graph of larval head capsule widths. A. *Euchloe ausonides,* San Francisco Bay area (Alameda, Contra Costa, and Santa Clara Counties); B. *Euchloe ausonides,* Buck Creek Ranger Station, Modoc Co., Calif.; C. *Euchloe olympia,* Michigan; D. *Euchloe hyantis,* California (Mariposa, Modoc, and Sierra Counties).

The successive instars of each *Euchloe* species display distinct trends in setal coloration and size. With each successive instar, size of primary setae becomes greater on *Euchloe ausonides* larvae, remains about the same on *Euchloe olympia* larvae, and becomes smaller on *Euchloe hyantis* larvae.

On first instar *Euchloe* larvae all primary setae are melanized. Ultimate instar larvae have dorsal and subdorsal primary setae darkened and the primary setae of lateral, subventral, and ventral areas demelanized.

The secondary setae which appear on *Euchloe* larvae in increasing numbers on successive instars also vary in size and prominence. The length of secondary setae becomes longer on larvae of *Euchloe olympia,* remains about the same on larvae of *Euchloe ausonides,* and become shorter on larvae of *Euchloe hyantis.*

The apparent color of secondary setae on ultimate instar larvae is uniformly pale on *Euchloe ausonides* larvae, and dark on dorsal and subdorsal areas of *Euchloe olympia* and *Euchloe hyantis* larvae.

The extent and melanization of the sclerotized setiferous chalazae and pinaculi also differs between species and successive instars of the same species. The sclerotized chalazae of *Euchloe ausonides* and *Euchloe olympia* larvae become greater in extent with each succeeding instar, remaining about the same proportion to larval size. The chalazae of *Euchloe hyantis* larvae become progressively smaller with each succeeding instar, paralleling the size decrease of the primary setae.

The sclerotized chalazae or pinaculi bearing primary setae are darkened on all areas of all instars of *Euchloe* larvae, with the exception of lateral areas on ultimate instar larvae of *Euchloe hyantis.*

The bases of secondary setae on all ultimate instar larvae are darkened on dorsal and subdorsal areas and pale on the lateral areas. On the subventral and ventral areas they are darkened on *Euchloe ausonides* and *Euchloe hyantis,* while most are pale on *Euchloe olympia* larvae.

Pupa. — Pupal marking and coloration is extremely variable. Some idea of the pupal coloration may be seen by referring to Plate 1, figs. 2 and 4.

Although the recurvature of *Euchloe* pupae is somewhat variable, the relative proportions of the pupae are slightly differentiated. Line drawings of the pupae (Figs. 16-18) show that the ratio of the cephalic portion to pupal length is greater

for *Euchloe ausonides* (.28) than for *Euchloe olympia* (.25) and *Euchloe hyantis* (.24). The dorsal surface of the cephalic portion of *Euchloe hyantis* pupae is slightly emarginate when viewed laterally.

SUMMARY

Certain features of the life history and morphology of the immature stages of *Euchloe* emphasize the division of the Nearctic members into two species groups. In particular, location of oviposition site, larval behavior, larval color pattern and chaetotaxy are characters whose condition in the two species groups indicates genetic isolation of long standing.

ACKNOWLEDGMENTS

The following individuals provided information or material representing the immature stages of *Euchloe* which proved invaluable in the construction of this paper: J. F. Emmel, Idyllwild, California; T. C. Emmel, Gainesville, Florida; Chris Henne, Pearblossom, California; E. J. Newcomer, Yakima, Washington; M. C. Nielsen, Lansing, Michigan; and Fred Thorne, El Cajon, California. Roland Fisher, Michigan State University, East Lansing, Michigan, kindly loaned larval material representing *Euchloe olympia.*

I am indebted to Wayne Steele, Livermore, California, for his preparation and provision of scanning electron photomicrographs of the egg of *Euchloe ausonides.*

Evert Schlinger, Division of Entomology, University of California, Berkeley, reviewed the manuscript of this paper and provided suggestions and corrections which were incorporated into the final draft.

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